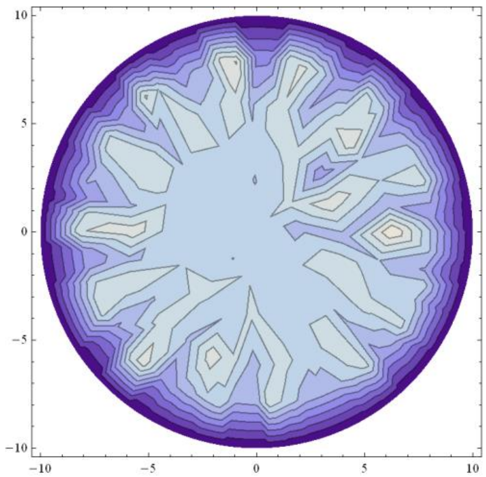
Current Research in Numerical Analysis

April 25, 2013, 9:30AM – 3:30PM

Science Center, Room 4102

Graduate Center, CUNY



Mathematical modeling provides a means to quantitize our observable world. Too often the equations that arise are intractable. Numerical Analysis provides the means to approximate these quantities and the theory to validate the correctness of the computed data. This symposium includes four presentations that demonstMathematical modeling provides a means to quantitize the observable world. Too often the equations that arise are intractable, and Numerical Analysis provides the means to approximate these quantities and the theory to validate correctness of the computed data. This one-day event, the eleventh of a symposium series at the Graduate Center of CUNY, aims to demonstrate aspects of the approximation/validation processrate aspects of the approximation/validation process.

Schedule:

- 9:30 – 10:00 Coffee
- 10:00 – 11:00 David Dritschel
- 11:15 – 12:15 Tim Kelley
- 12:15 – 1:15 Lunch

- 13:15 – 14:15 Jie Shen
- 14:30 – 15:30 Yves Bourgault
- 15:30 – 16:30 Discussion perhaps on future directions

Titles and Abstracts:

1. David Dritschel, Dept of Mathematics, St. Andrews Univ., UK, dgd@mcs.st-and.ac.uk

Fast, accurate numerical methods for modeling layerwise two-dimensional flows

There are many naturally occurring flows which exhibit strong anisotropy due to constraints imposed by, for example, rotation and stratification. Prime examples include the atmosphere and oceans, other planetary atmospheres (as on the gas giants), and even the interior of the sun, which exhibits a stably stratified and magnetized zone called the `tachocline'. This talk first explains why these constraints naturally lead to layerwise two-dimensional motion, with exceptionally weak vertical velocities over a vast range of scales. Then, a novel computational method is described which, arguably, is ideally suited to the study of such strongly anisotropic flows. The method, called "contour advection", uses grid-free contours to accurately and stably represent nonlinear advection in conjunction with conventional grid-based techniques. This method combines the fast, accurate components of various methods to achieve unprecedented gains in numerical efficiency and accuracy. A variety of applications are illustrated, from shear-layer instability, density currents, banded circulation patterns and jet streams in planetary atmospheres, to magnetohydrodynamical turbulence at essentially infinite Reynolds number.

2. C. T. Kelley, Dept of Mathmatics, North Carolina State University, tim_kelley@ncsu.edu

Newton's Method for Monte Carlo-Based Residuals

We analyze the behavior of inexact Newton methods for problems where the nonlinear residual, Jacobian, and Jacobian-vector products are the outputs of Monte Carlo simulations. We propose algorithms which account for the randomness in the iteration, develop theory for the behavior of these algorithms, and illustrate the results with an example from neutronics.

3. Jie Shen, Dept of Mathematics, Purdue University, jxs28b@gmail.com

Some recent advances on phase-field models for multiphase complex fluids

I shall present some recent work on phase-field model for multiphase complex fluids. Particular attention will be paid to develop models which are valid for problems with large

density ratios and obey an energy dissipation law. I shall present efficient and accurate numerical schemes for solving the coupled nonlinear system for the multiphase complex fluid. In many cases, these schemes are decoupled and energy stable. I'll also provide ample numerical results which not only demonstrate the effectiveness of the numerical schemes, but also validate the flexibility and robustness of the phase-field model.

4. Yves Bourgault, Dept of Mathematics and Statistics, University of Ottawa, ybourg@uottawa.ca

Error estimation and anisotropic mesh adaptation

Abstract: Anisotropic mesh adaptation has proved to be a powerful strategy to improve the accuracy and efficiency of finite element methods. These anisotropic mesh adaptation techniques were initially based on a metric derived from a numerical approximation of the Hessian of the solutions with, in the background, the use of *a priori* error estimates. More recently, anisotropic *a posteriori* error estimators were derived and used to do anisotropic mesh adaptation. These *a posteriori* estimators have been initially developed for elliptic partial differential equations. The extension of these estimators and of anisotropic mesh adaptation to parabolic and hyperbolic equations poses several challenges, in particular due to the unsteadiness or the eventual lack of regularity of the solution. In my talk, I will review the two main approaches for anisotropic error estimation, namely *a priori* and *a posteriori* error estimation, briefly cover the main methods for generating anisotropic meshes and address some of the issues in extending the methodology to unsteady phenomena and less regular solutions. Numerical results will be presented to illustrate the efficiency of the methods.

Organizers:

John Loustau, Dept of Math and Stat, Hunter College CUNY

Marcello Lucia, Dept of Math, CSI CUNY

Sponsoring organizations:

Initiative for Theoretical Science, CUNY Graduate Center

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